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BUILDING WATER PIPE SIZING

DAUNTING REALITIES FOR ASSESSING NEW DEMANDS

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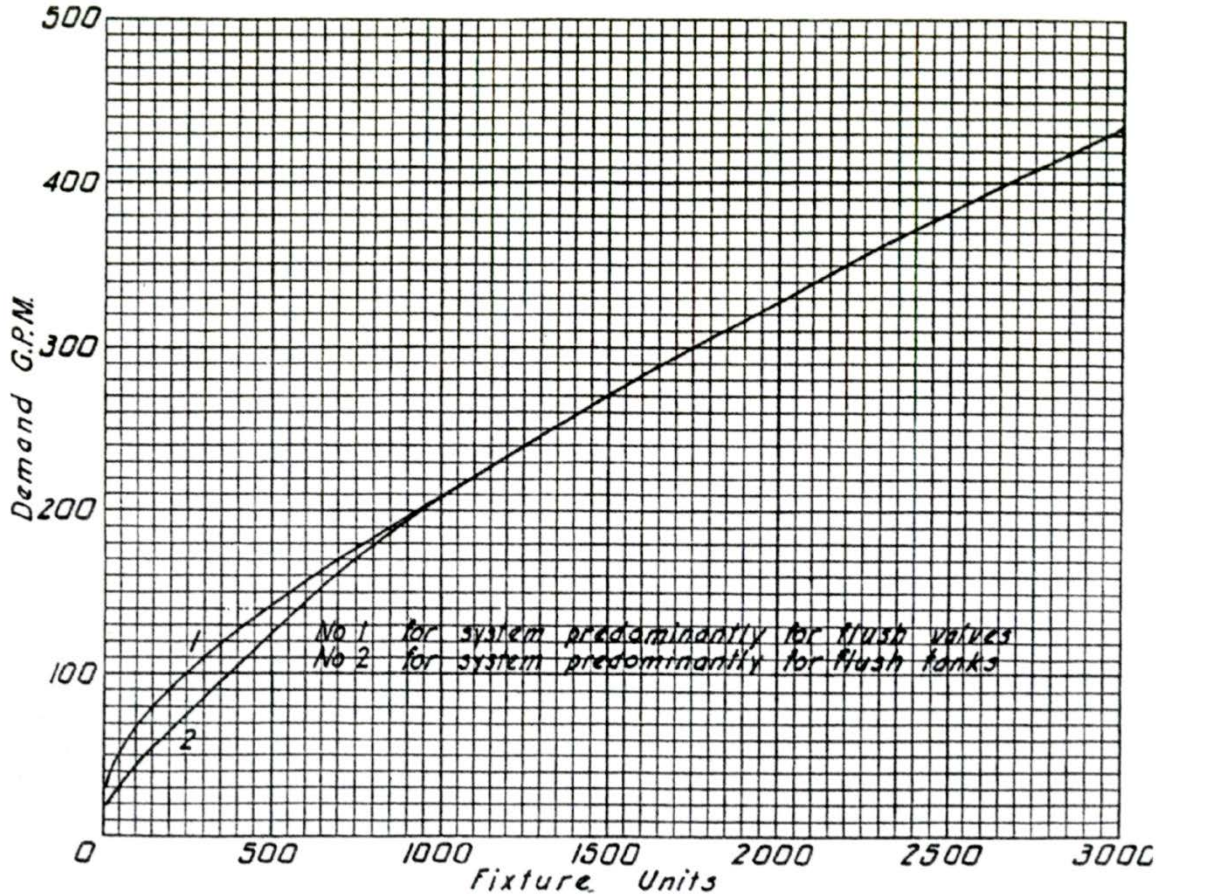
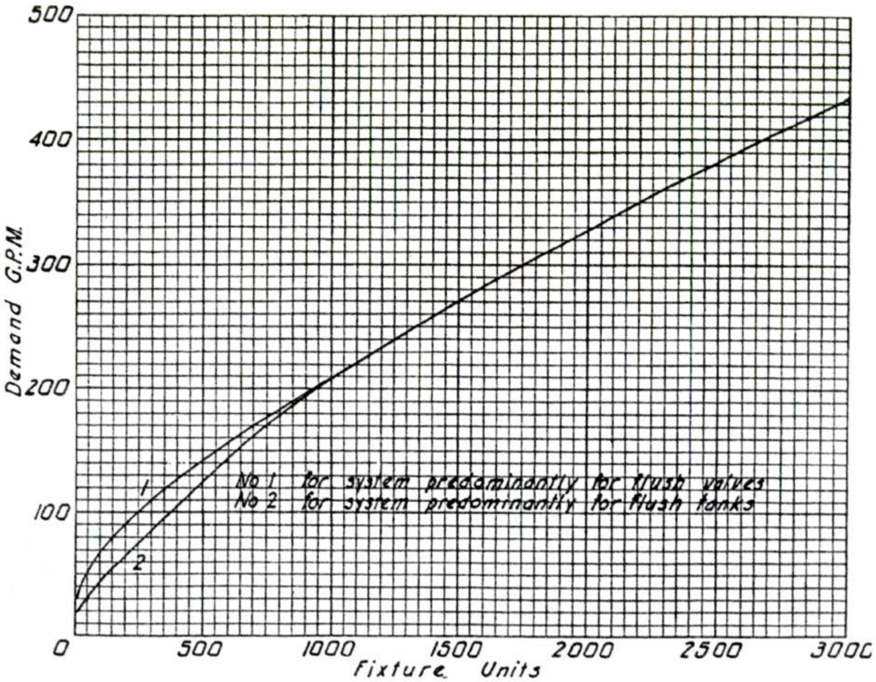
What's the Problem?

- Dr. Roy Hunter – National Bureau of Standards – develops "Hunter's Curve" in the 1920's – 1940's
- NBS (now NIST) closed the plumbing research program in the 1970's



What's Hunter's Curve?

- Hunter's Curve, is a probability design curve indicating the relation of the water supply demand to "fixture units"
- A fixture unit is a scaled number assigned to a plumbing fixture weighted relative to the flushometer-valve toilet.
- The plumbing industry has utilized this estimating methodology since the 1920s
- All plumbing codes still incorporate the curve values in order to estimate the total water supply demand for a building.



Hunter's curve takes (1) the number of fixtures, (2) flow rate demand for those fixtures and (3) duration of activation into account

Distinct Differences for Residential & Commercial Buildings

- Note that there are two curves at the lower end of the curve
  - These represent the difference between flushometer-valve (commercial) toilets and tank type gravity toilets
  - Flow demand requiremen for commercial toilets are much higher

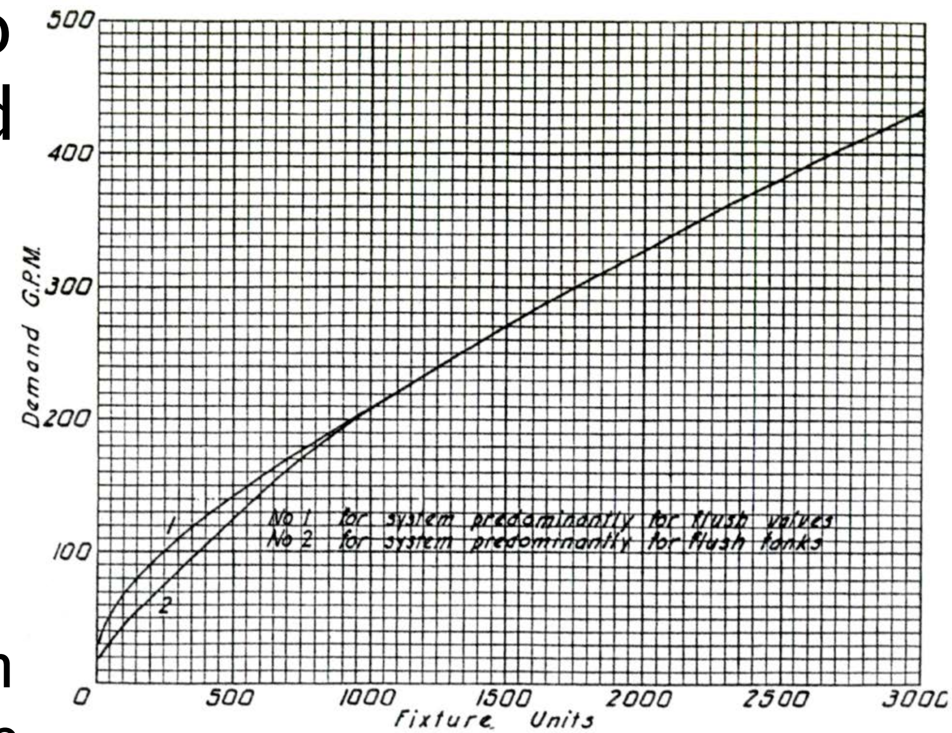


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Table 1
Flow Reductions in Plumbing Fixtures and Fixture Fittings

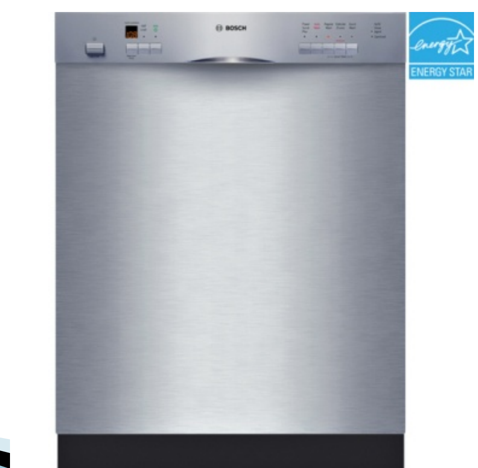
Plumbing Device	Pre 1990 Flow Rates	1990 Requirement	2009 Base Line Code Requirement	% Reduction	2010 GPMCS Provision	Total % Reduction from 1990 levels
Bathroom Faucet	3.5 gpm+	2.5 gpm	2.2 gpm	12%	1.5 gpm	40%
Showerhead	3.5 gpm+	3.5 gpm	2.5 gpm	29%	2.0 gpm	43%
Toilets – Residential	5.0 gpf +	3.5 gpf	1.6 gpf	54%	1.28 gpm	63%
Toilets – Commercial	5.0 gpf+	3.5 gpf	1.6 gpf	54%	1.6 gpf* (drainline)	54%
Urinals	1.5 gpf to 3.0 gpf+	1.5 gpf to 3.0 gpf	1.0 gpf	33%	0.5 gpf	67%
Commercial Faucets	3.5 gpm+	2.5 gpm	0.5 gpm	80%	0.5 gpm	80%
Pre-rinse Spray Valve	No requirement+	No requirement	No requirement	N/A	1.3 gpm	>50%

Reductions come in two forms:

(1) reduction in flow rate with minor or uncertain corresponding reduction in activation time (showerheads)

(2) reduction in activation time with little or no reduction in flow rate (toilets)

Appliance Demands Also Significantly Reduced



Residential Clothes washers

Cycles--Heavy Load

psi- 35	Average		
Vertical Axis	H	C	M
Fill Flow Rate (gpm)	2.58	3.36	2.97
Volume of Water (gal)	39.58		

psi- 35	Average		
Horizontal Axis	H	C	M
Fill Flow Rate (gpm)	2.73	2.66	2.40
Volume of Water (gal)	13.73		

Residential Dishwashers

Cycles--Heavy Load

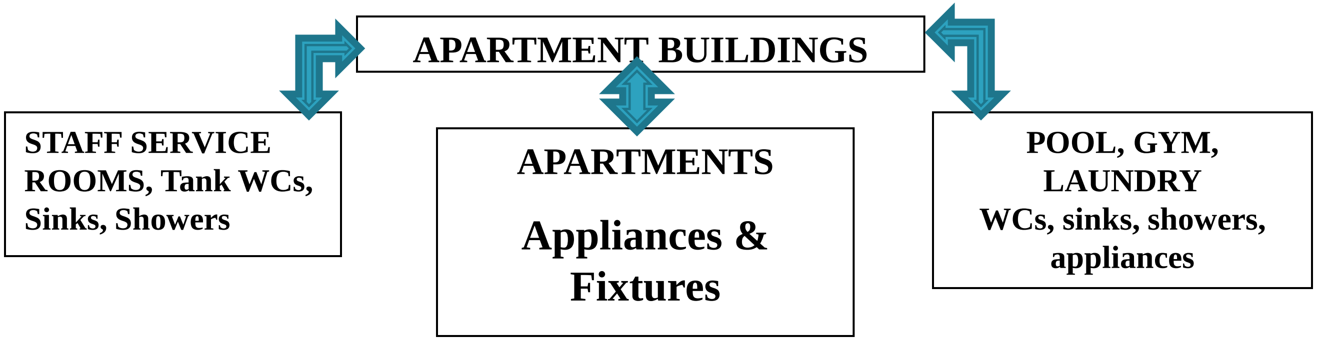
psi - 35	Average	High	Low
Fill Flow Rate (gpm)	0.96	-	-
Volume of Water (gal)	5.70	10.00	2.35

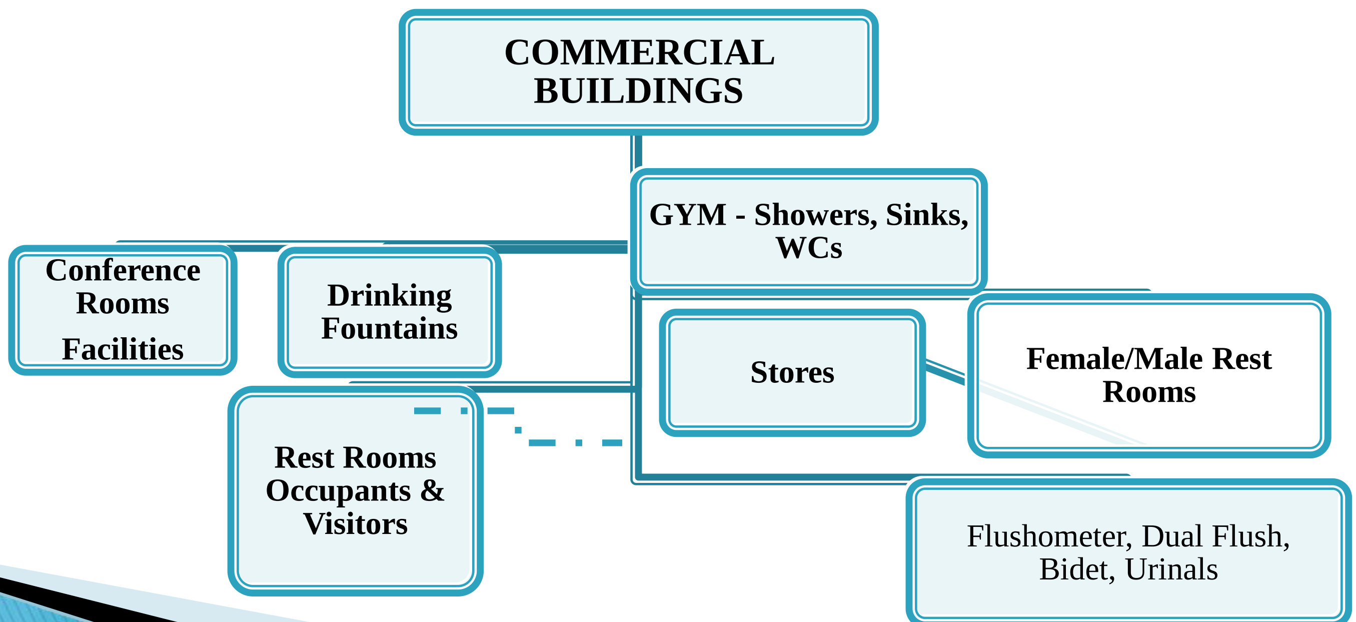
Concerns About Unintended Consequences of Water Efficiency

- What's the Problem? We are currently over-sizing our plumbing systems due to outdated demand estimate models
- Over sized water supply pipes may result in:
  - Longer wait times for hot water to arrive at point of use – wasted energy
  - Lower velocities in pipes, less scouring action, possible increase of biofilm growth
  - This Concern is magnified in health care facilities
    - John Hopkins Report regarding electronic faucets
    - ASPE led effort to investigate

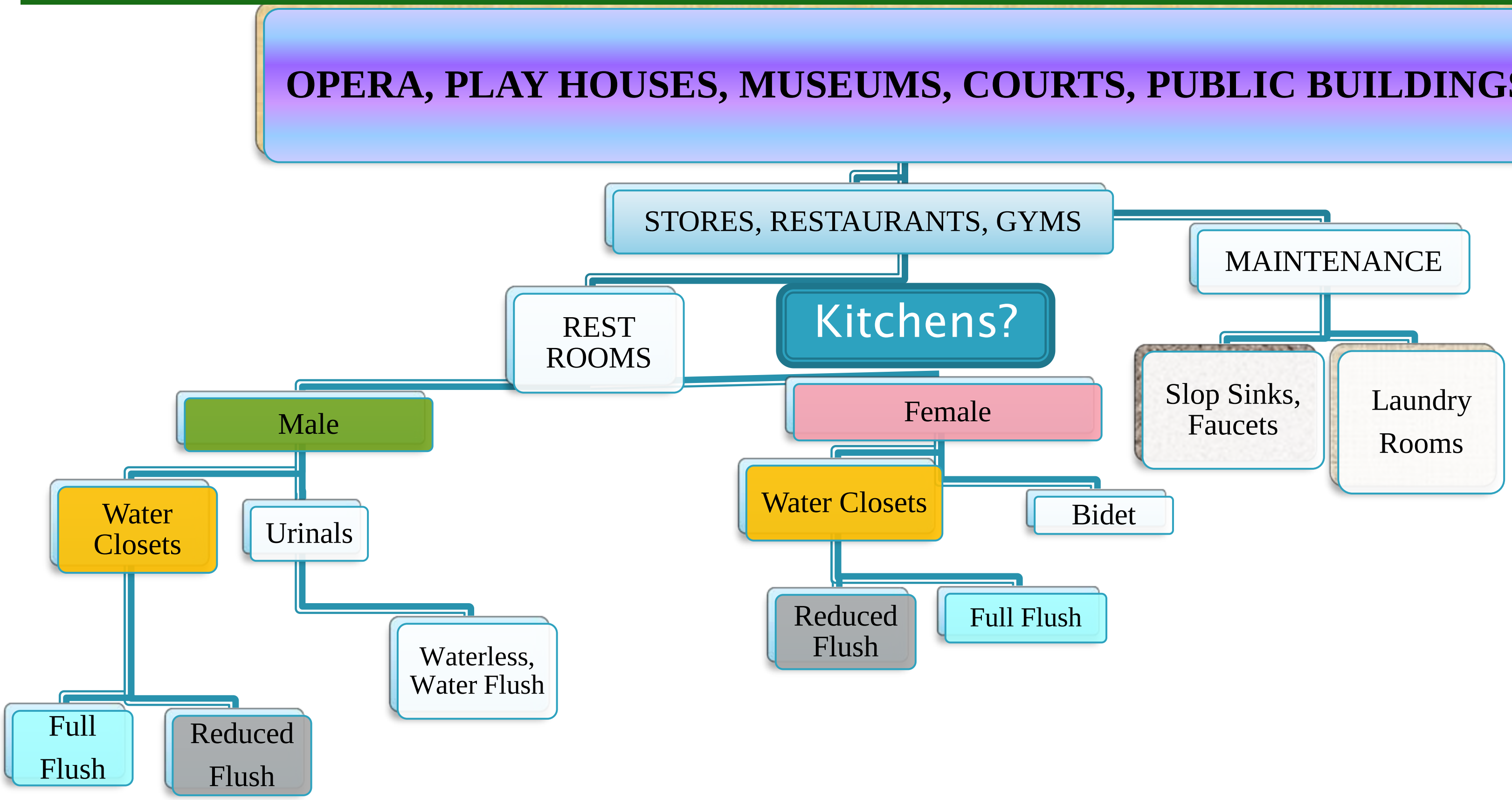
REAL BUILDING DIFFERENCES

Larger Buildings Increase Complexity And Uncertainty



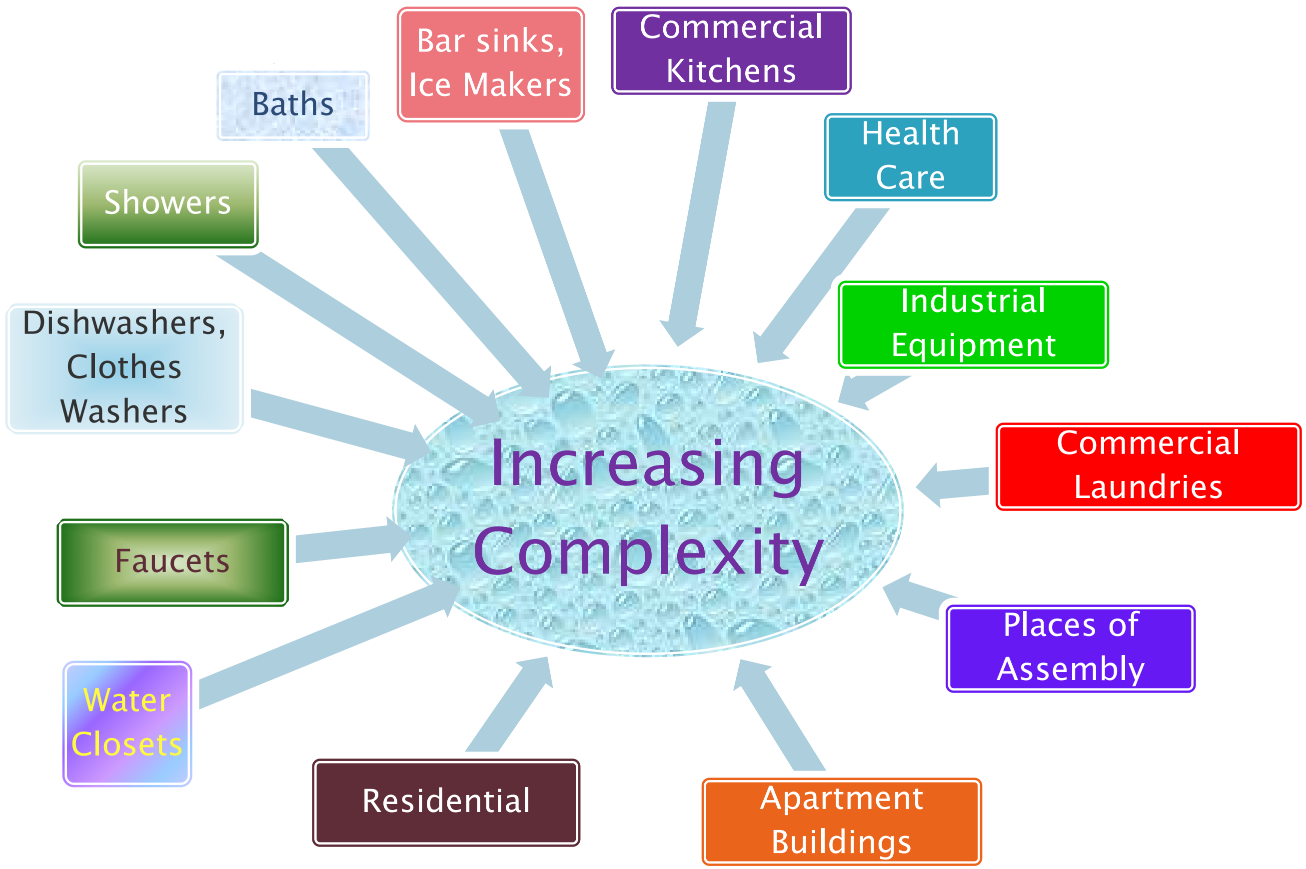


Commercial Buildings Example



SIMULTANEOUS EVENTS
APPLIANCES/FIXTURES GROUPINGS

Simultaneous sets within and between each action group



What Can Go Wrong?

- Dr. Roy Hunter defines failure: NBS 65 (1940) "… greatest number of fixtures out of n that will be in operation 1 percent of the time and m is the number of fixtures that will not be exceeded more than 1 percent of the time."
  - In other words, we size the system to ensure enough residual pressure 99% of the time and accept that 1% of the time simultaneous demand will exceed the system's design
- Under-sizing risks:
  - We exceed the 1% failure rate
  - Velocities too high (consider removable flow restrictors!)
    - Excessive Noise
    - Erosion corrosion over time – premature pipe leaks
  - Insufficient residual pressure
    - Increased risk in thermal shock / scalding while showering
    - Flushometer-valves may not shut off
    - Insufficient water flows to commercial / industrial equipment

The Path Forward

- Current Efforts: A cautious and incremental approach required
  - Data Gathering (ongoing)
    - Current flow rate and consumption data on plumbing fixtures and fixture fittings provided by PMI Members (American Standard Brands, Kohler, Fluidmaster, WDI and others)
    - Current flow rate and consumption on appliances provided by AHAM
    - Review of residential home study data from Aquacraft
    - Review of available AWWA demand data and distribution pipe sizing requirements
    - Review of residential user behavior data from Masco R&D "Environments for Living" program

The Path Forward

- IAPMO Pipe Sizing Task Group
  - Sub-committee to the Green Technical Committee that develops the IAPMO Green Plumbing and Mechanical Code Supplement – Chair, Dan Cole
  - Coordinating data gathering efforts
  - ASPE appoints experts in statistical analysis
    - Reviewing alternative statistical models to improve upon / replace Roy Hunter's
      - Monte Carlo, SIMDEUM and Wistort models are under consideration. Fuzzy logic and Poisson Rectangular Pulse models have been determined unsuitable for this application
    - "The problem at hand is the need to develop a statistical model that has the best potential to predict the peak demand for various water use habits associated with the need of the building type." – Dan Cole

Conclusions & Recomendations

- Revision of Hunter's Curve Probability Fixture Unit method is an emerging requirement for both health and safety and water/energy conservation concerns
- Research Needed!
  - Field data measurements for multi-family and commercial buildings in U.S. are not available
  - Better understanding of potential simultaneous usage of water consuming fixtures, appliances and equipment in buildings
  - Determination if a superior statistical model exists to estimate demand versus Hunter's approach
- Conservative and incremental steps forward recommended

Questions?

THANK YOU!

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